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An Experimental Study on Insertion of Vinyl Tube in Portal Vein

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CONTENT

I. INTRODUCTION

Treatment of cancer in the pancreatic head can be pointed out as one of the most difficult problems of present medicine. A successful case of pancreatoduodenectomy, which was postulated by HALSTED as a treatment for cancer in the pancreatic head, was first reported by WHIPPLE[48] in 1935. Resectability, studies on the method and remote result of this operative maneuver were reported thereafter by BRUNSCHWIG[6,7] CHILD, STAFFORD[42], RHOADS[38] and others and many enthusiastic studies have been made on this operation. The resectability, however, remains to be extremely low and very few cases of 5 year survival have been reported.

Unfavorable result of pancreatoduodenectomy might be firstly due to the fact that early diagnosis of cancer in the pancreatic head is utterly difficult and most cases are not subjected to laparotomy until disclosure of jaundice, and secondly due to the fact that the pancreatic head is so closely situated to the portal vein anatomically that adhesive infiltration to the latter is commonly observed, which rejects the resection even in cases in which the resection is otherwise considered to be feasible.

Here, as an attempt to improve the resectability, it is necessarily required to establish certain method of pancreatoduodenectomy in which hemorrhage can be minimized even if the portal vein be injured.

CHILD[9,10], in 1950, devised a method using macaca mulatta monkeys, in which operation is carried out in 2 stages. At the initial operation, the portal ligation is performed, which is followed by simultaneous resection of the portal vein with pancreatoduodenectomy 7 to 10 days later, at which time adequate descension of portal pressure is expected owing to development of collaterals. Principal aim of this method consists in minimizing hemorrhage during and after the operation caused by congestion of portal blood. He later reported 4 successful clinical cases. However, according to the study of HONJO[19], performance of the 'two stage operation' is difficult, because descension of portal pressure is not so pronounced as expected and not only hepatofugal but also hepatopetal collaterals are observed at the 2nd operation and in the respect of preventing hemorrhage, it has not so much advantage as was expected. On the other hand, experiments have been carried out on vessel transplantation and synthetic graft transplantation for simultaneous resection of the portal vein.[1,3,13,15,24,40,46,47] However, the complexity of this method cannot be denied since it requires vessel transplantation for the reconstruction of the portal vein in addition to the technically toilsome and largely aggresive operation of pancreatoduodenectomy.

The author of the present experiment intended to improve resectability of pancreatoduodenectomy by easy simultaneous resection of the portal vein around the vinyl tube which was inserted into the portal vein, and carried out experimental study on the time of portal occlusion due to thrombus formation after portal tubing, change of arterial and portal pressure, development of hepatopetal collaterals and histological findings of the liver and portal vein following the portal tubing. It was further studied whether there is a dangerous

possibility of sliding off of the inserted tube by stripping of the portal wall of the site of tubing. Experiment of wrapping with tetoron mesh around the exposed vinyl tube after stripping of the portal wall, was carried out for this purpose and some interesting informations were obtained.

II. EXPERIMENT OF INSERTION OF VINYL TUBE IN PORTAL VEIN

1. Materials and methods

A. Materials

Adult mongrel dogs weighing 6 to 13.5 kg were used. Experiment of vinyl tube insertion into the portal vein was carried out under general anesthesia of intravenous injection of ravonal of 13mg/kg body weight and ether inhalation. Vinyl tubes to be inserted had about 3 cm in length and caliber of 4, 5 and 6 mm, with wall thickness of 1 mm. Inside of the both ends of the tube was pared in a shape of funnel, The tube was immersed in 25% silicone solution KF 96 for about 5 minutes and dried, which was further immersed at use in 70% alcohol solution for an hour and then in 20 ml of Ringer's solution containing 100,000 u. of penicillin for 30 minutes (Fig. 1).

Fig. 1. Preparation of vinyl tube.

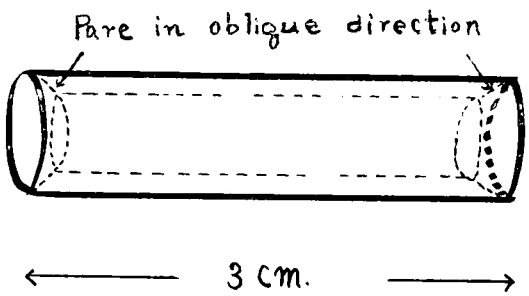
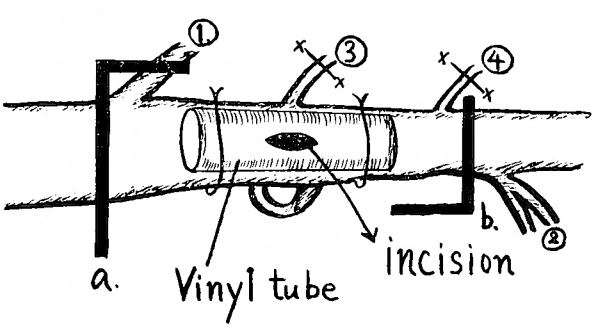


Fig. 2. Insertion of vinyl tube.



① V. gastroduodenalis
② V. mesenterica superior (1 st and 2nd branch)
③ V. lienalis } severance
④ V. mesenterica inferior }
a, b. interruption

B. Methods

1) Procedure of portal tubing

The abdomen was opened with upper median incision and right transverse incision was added. Portal trunk was isolated from the surrounding tissues for the length of 2 times of the to-be-inserted tube. The splenic and inferior mesenteric veins were ligated and cut at the draining site to the portal vein. The spleen was extirpated. The portal vein was temporarily interrupted at the liver side of the draining of the gastroduodenal vein together with this vein and the intestinal side of the draining of the inferior mesenteric vein. During the interruption, a small incision was laid on the portal trunk at the level of the splenic vein draining, from which a vinyl tube of suitable size was inserted into the portal vein. Both ends of the inserted tube were tightly ligated with silk-thread. Immediately after the fixation of the tube, the interruption was released (Fig. 2).

2) Experiment on influence of severance of gastroduodenal vein and 1st and 2nd

branches of superior mesenteric vein on collaterals development

As it was considered in the preliminary experiment that the gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein may play an important role concerning collaterals development in experimental dogs of portal tubing as will be described in the below, observation was done in the following 3 groups.

i. Group without severance of the gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein.

ii. Group with severance of the gastroduodenal vein.

iii. Group with severance of 1st and 2nd branches of the superior mesenteric vein.

3) Experiment of acute portal interruption

As control of the above mentioned 3 groups, following experiment was carried out without portal tubing and severance of the gastroduodenal and superior mesenteric veins.

i. Acute portal interruption at the liver hilum.

ii. Acute portal interruption at the intestinal side of the splenic vein draining.

4) Observations following portal tubing

Following observations were carried out after portal tubing in experimental animals. Anticoagulant was not used pre- and postoperatively.

i. Time of portal occlusion due to thrombus formation and changes of arterial and portal pressures

ii. Observations on collaterals following portal occlusion due to thrombus formation

iii. Experimental studies of development of hepatopetal collaterals

iv. Cardiac and hepatic function after portal tubing

v. Body weight after portal tubing

vi. Histological studies of liver after portal tubing

vii. Histological studies of portal vein after portal tubing

2. Results

1) Time of portal occlusion due to thrombus formation

Time of portal occlusion due to thrombus formation was observed by portalography using 50 % urographin and measurement of portal pressure every 5 minutes through a polyethylene tube which was inserted at portal tubing from a branch of the superior mesenteric vein to the portal vein and remained after closure of the abdomen.

i. Change of portal pressure until portal occlusion due to thrombus formation

Portal pressure gradually elevated as time elapsed after portal tubing as shown in Fig. 3. With a rapid elevation of portal pressure, the portal vein was occluded. Portal pressure descended thereafter and showed slightly higher level than that before occlusion which was, however, within normal range, and maintained this level for long. The pressure remained in the restored level for long.

ii. Time of portal occlusion due to thrombus formation

Portal occlusion due to thrombus formation was observed at earliest 20 hours and at latest 62 hours after the tubing in the present experiment, as is shown in Tab. 1 and Fig. 4. Portal pressure was 10 mmH_2O higher immediately after release of portal interruption than the initial level. But the pressure was as high as about 3 times of initial level immediately after portal occlusion due to thrombus formation. Time of portal thrombus formation was pursued by portalography using 50% urographin as mentioned in the above.

Fig. 3. Change of portal pressure.

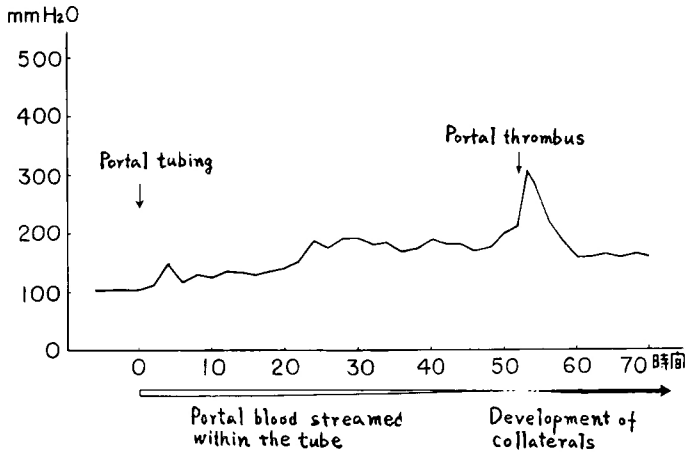
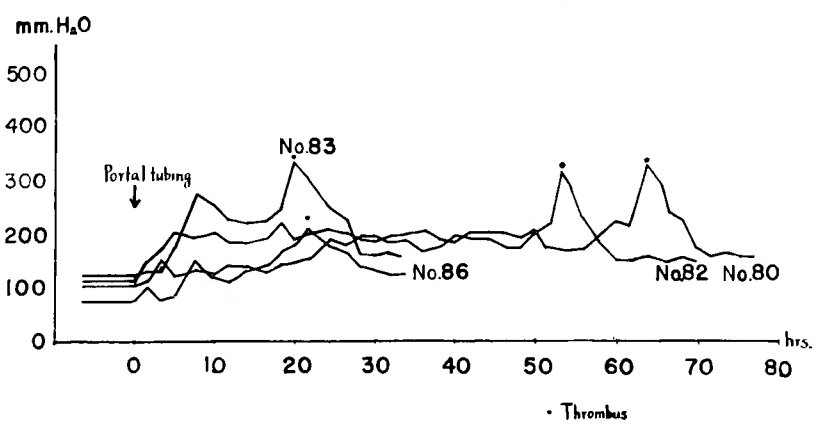


Table 1. Time of portal occlusion caused by thrombus and portal pressure after portal tubing.

Dog No.	Time of occlusion due to thrombus (hrs.)	Initial portal pressure (mm H_2O)	Portal pressure immediately after release of interruption (mm H_2O)	Portal pressure immediately after occlusion (mm H_2O)	Portal pressure 1 week after occlusion (mm H_2O)
79	25	110	140	342	180
80	62	110	120	325	190
81	25	103	115	286	210
82	54	105	112	310	155
83	20	120	125	334	175
84	35	92	103	297	186
85	24	105	115	348	170
86	22	75	80	210	132

Fig. 4. Change of portal pressure.



Time of collaterals accomplishment was observed almost simultaneously with portal occlusion due to thrombus (Fig. 5). In Fig. 5, a, the portal vein is completely patent, and in Fig. 5, b, the lumen of the portal vein is slightly narrowed by thrombus formation on the portal wall 21 hours after the tubing, at which time portal pressure was as high as 3 times of the level before the tubing. In Fig. 5, c, the portal vein is completely occluded by thrombus 62 hours after the tubing, at the same time showing development of hepatopetal collaterals.

iii. Long observation on arterial and portal pressures after portal tubing

Portal and arterial pressures were measured with laparotomy 1 week, 2 weeks, 3 weeks, 2 months and 4 months after portal tubing. Portal pressure had already restored to normal level and stabilized, and arterial pressure was also maintained without marked change (Fig. 6).

2) Observations on collaterals after portal occlusion due to thrombus formation following portal tubing

i. Observations on collaterals by portalography

In surviving dogs after portal occlusion due to thrombus formation following portal tubing, portalography was performed with laparotomy using 50 % urographin 1 week, 2 weeks, 3 weeks and 8 weeks after the tubing. Hepatopetal and sometimes hepatofugal

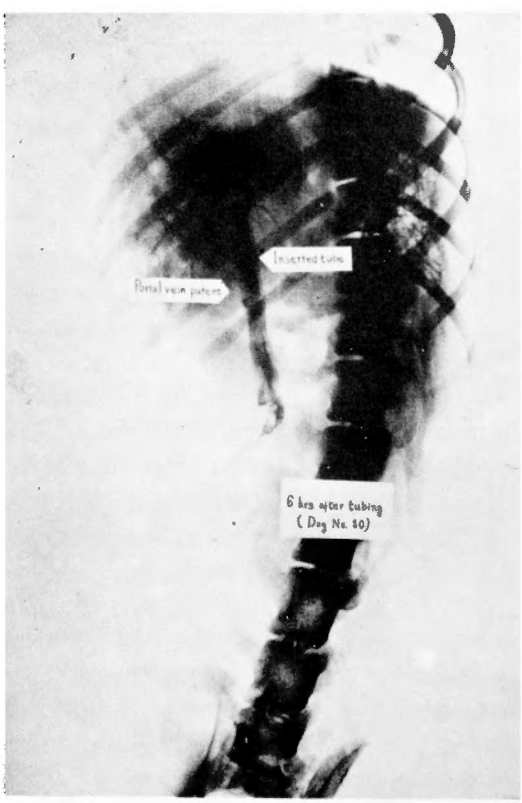


Fig. 5. a. Six hours after portal tubing
(Portal vein remained patent.)

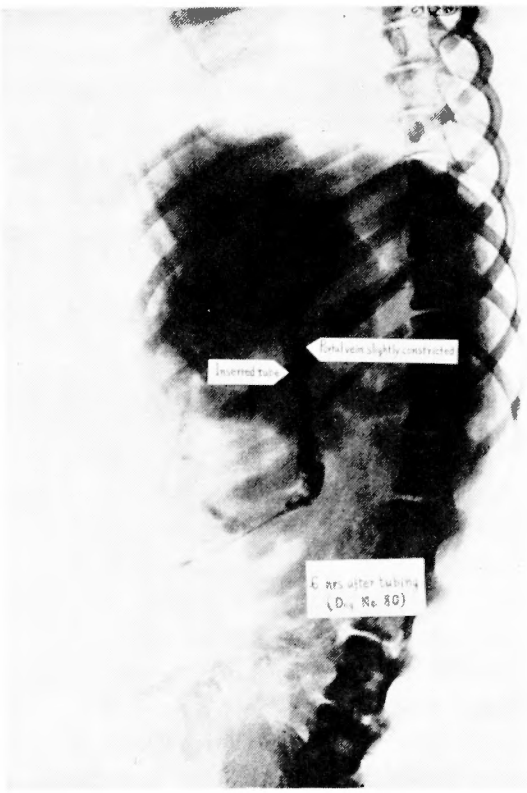


Fig. 5. b. Twenty-one hours after portal tubing.(Portal vein being slightly constricted by thrombus on the wall.)

Fig. 5. c. Sixty-two hours after portal tubing. (Portal vein being occluded by thrombus, hepatopetal collaterals being developed.)

collaterals were observed. Portalography in the same dog revealed no particular change in the degree and size of collaterals until postoperative remote period (Fig. 7, a, b, c and d).

ii. Anatomical study of collaterals

The abdomen was opened in surviving dogs which showed collaterals by portalography after portal occlusion due to thrombus formation following portal tubing, and hepatopetal collaterals were anatomically studied. It was ascertained that the collaterals course as follows; the portal vein—superior mesenteric vein—intestinal vein—inferior pancreatoduodenal vein—superior pancreatoduodenal vein—gastroduodenal vein—portal vein.

3) Experimental study of hepatopetal collaterals

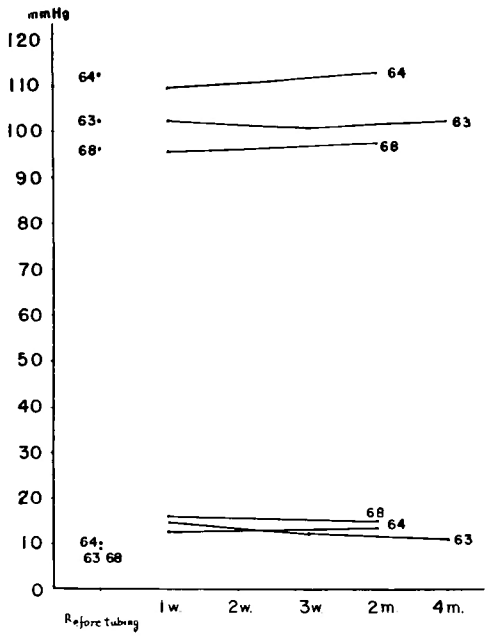
As mentioned in the above, as it was considered that the gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein play an important role in collaterals development in the dogs of portal tubing, experiment was carried out in 3 groups.

I. Group without severance of the gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein.

II. Group with severance of the gastroduodenal vein.

III. Group with severance of 1st and 2nd branches of the superior mesenteric vein.

Fig. 6. Changes of arterial and portal pressures after portal tubing in animals with severance of V. lienalis and V. mesent. inf. with patent V. gastroduod. and V. mesent. sup.



In the group I, animals survived in 77% (Tab. 2). Survival rate may become nearly 100%, if the technical error is taken into account.

In the group II and III, portal pressure began to rise as in Fig. 8 and 9 after release of portal interruption during procedure of portal tubing and reached the level of 400 to 550 mmH_2O, while arterial pressure gradually fell, which was followed by descension of both pressures thereafter. Finally there appears marked congestion in the intestine and all the animals were led to death within 4 to 6 hours.

From these findings, it was ascertained that participation of the gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein is indispensable for an establishment of collaterals in dogs after portal tubing.

4) Acute portal interruption

As control of the above mentioned 3 groups, acute portal interruption was performed without severance of the gastroduodenal and superior mesenteric veins and portal tubing[25,29].

i. Interruption at liver hilum

Interruption was performed at the liver hilum in 5 animals. All the animals died of shock due to splanchnic congestion within 40 to 80 minutes.

ii. Interruption at intestinal side of splenic vein draining

Interruption was performed at the intestinal side of the splenic vein draining in 8 animals. All the animals died of shock due to splanchnic congestion within 2 hours and 40 minutes to 4 hours (Tab. 3). Change of portal and arterial pressures is summarized in Fig. 10.

Thus animals invariably died following acute interruption, the gastroduodenal and superior mesenteric veins without being utilized as collaterals, even if these vein were preserved.

5) Cardiac function of surviving animals after portal tubing

In cardiac function, no marked change was found as is represented in Fig. 11, a and b.

6) Liver function of surviving animals after portal tubing

Bromsulphalein of 5 mg/kg body weight was intravenously injected and the retention rate was estimated 10 minutes after the injection with colorimeter. From observations carried out 1 week, 2 weeks, 1 month, 2 months, 3 months, 4 months and 5 months after the portal tubing, impairment of liver function was not found[23,43,44] (Fig. 12).

Fig. 7. a. A week after portal tubing

Fig. 7. b. Two weeks after portal tubing

Fig. 7. c. Three weeks after portal tubing.

Fig. 7. d. Eight weeks after portal tubing (The same dog as in Fig. 7. b.)

Table 2. Results of vinyl tube insertion. (in animals without severance of V. gastrod. and V. mesent. sup.)

	Duration of time of portal interruption. (min)	Result	Length of tube (mm)	Diameter of tube (mm)	Cause of death
61	8.00	Died after 8 hours	30	5	Bleeding
62	6.00	Died after 4 hours	30	5	Death associated with anesthesia
63	4.30	Slaughter at 63rd day	35	6	—
64	6.00	Slaughter at 184th day	35	5	—
65	4.20	Died after 6 hours	35	5	Bleeding
66	4.30	Slaughter at 95th day	35	5	—
67	7.00	Died after 3 hours	30	5	Meandering of portal vein
68	7.20	Slaughter at 224th day	28	6	—
69	6.00	Slaughter at 189th day	30	5	—
70	6.30	Slaughter at 180th day	30	5	—
71	9.10	Died after 3 hours	31	4	Bleeding
72	9.00	Slaughter at 152th day	30	4	—
73	8.10	Slaughter at 60th day	31	5	—
74	13.00	Slaughter at 58th day	31	5	—
75	9.00	Died after 5 hours	31	5	Bleeding
76	6.00	Slaughter at 118th day	31	5	—
77	7.30	survival	31	4	—
78	6.30	〃	31	5	—
79	6.00	〃	31	6	—
80	4.30	〃	31	5	—
81	8.00	〃	31	5	—
82	8.20	〃	31	5	—
83	7.30	〃	31	4	—
84	5.00	〃	31	5	—
85	4.00	〃	31	4	—
86	4.00	〃	31	5	—

7) Body weight of surviving animals after portal tubing

Body weight was observed until 6 th month every month. Weight loss was not observed (Fig. 13).

8) Histological finding of liver of surviving animals after portal tubing (Fig. 14)

Particular change was not observed.

9) Histological finding of portal vein of tubing site after portal tubing

Slight disorder of arrangement was observed in muscular layer of the portal wall, with necrotic change in parts. Both ends of the inserted tube were filled with granulation, revealing a finding of foreign body inflammation. Inside of middle portion of the inserted tube was filled with slightly fluidy fibrin-like substance[37]. (Fig. 15)

Fig. 8. Changes of arterial and portal pressures after release of portal interruption in animals of portal tubing with V. gastroduod. severance.

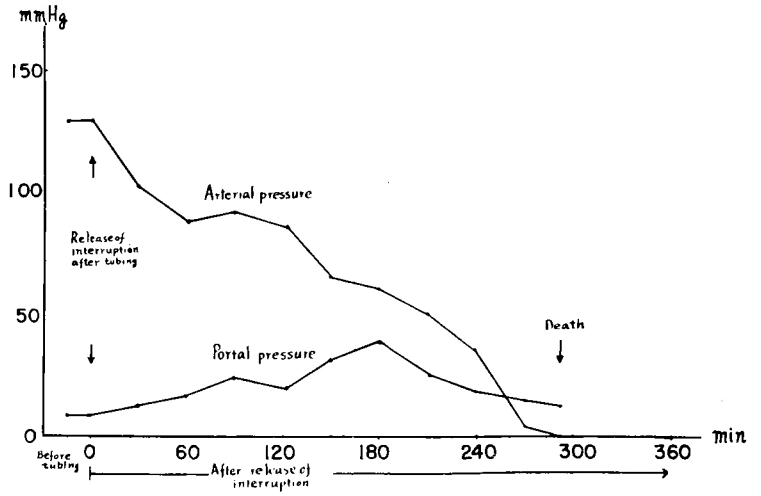


Fig. 9. Changes of arterial and portal pressures after release of portal interruption in animals of portal tubing with 1st and 2nd branches of V. mesent. sup. severance.

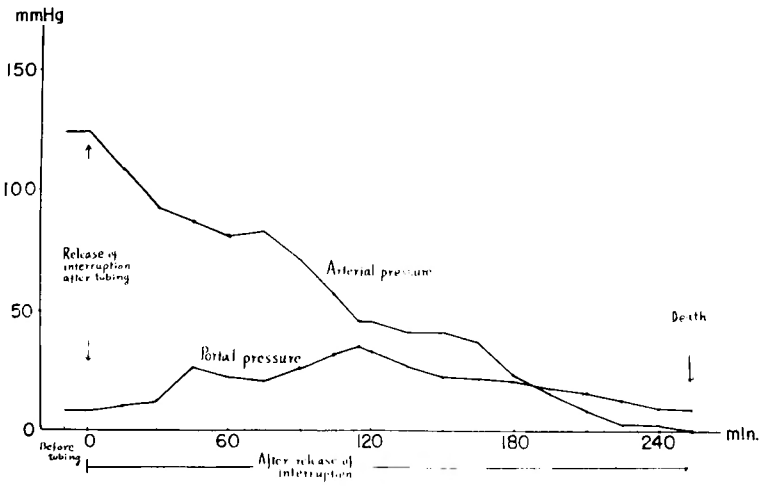


Table 3. Acute portal interruption at intestinal side of splenic vein draining. Death in all 8 cases.

Dog No.	Survival time	Cause of death
30	3 hrs 10 min	Gastrointestinal bleeding
31	3 〃 50 〃	〃
32	2 〃 40 〃	〃
33	3 〃 30 〃	〃
34	4 〃 0 〃	〃
35	2 〃 50 〃	〃
36	3 〃 50 〃	〃
37	3 〃 30 〃	〃

Fig. 10. Changes of arterial and portal pressures after acute portal interruption at intestinal side of splenic vein draining.

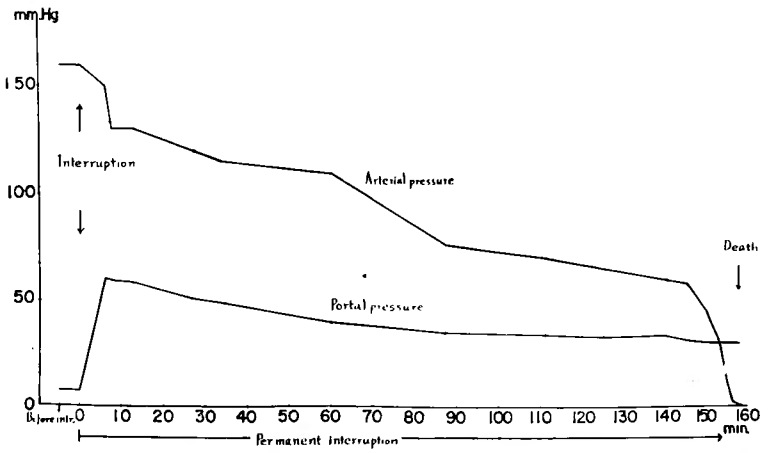


Fig. 11. a. Before interruption.

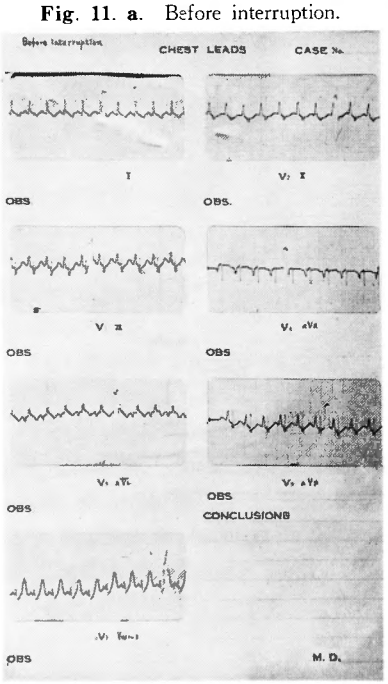


Fig. 11. b. Two months after portal tubing.

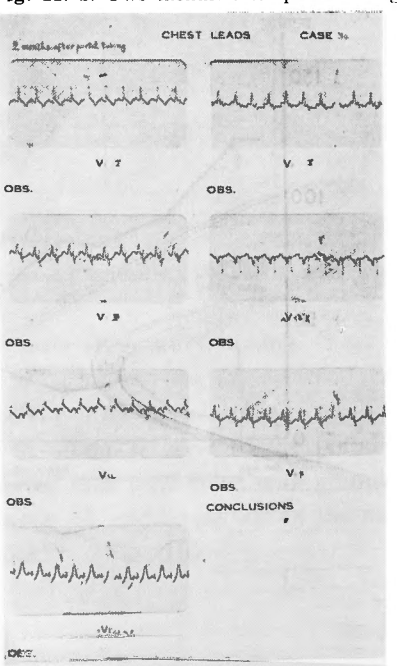


Fig. 12. B. S. P. retention test at 10th minute.
(Bromsulphalein 5mg/kg)

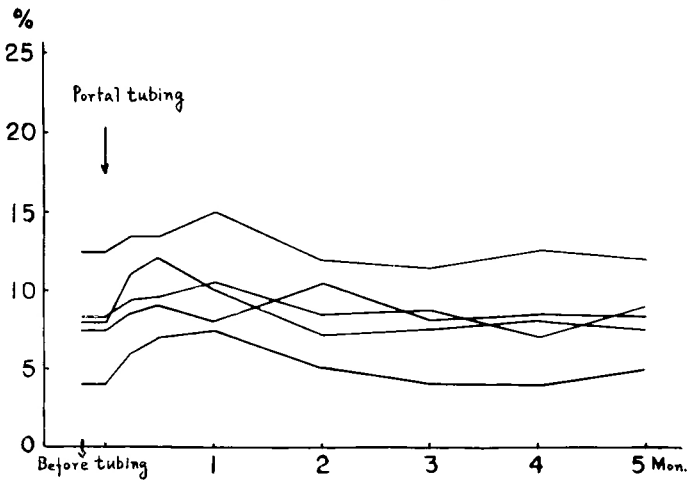


Fig. 13 Change of body weight after portal tubing.

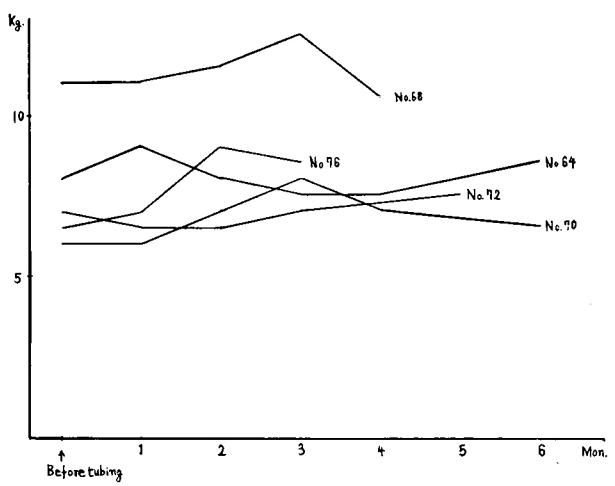


Fig. 14. Finding of liver, 184 days after portal tubing. Dog No.64 (H-E×100)

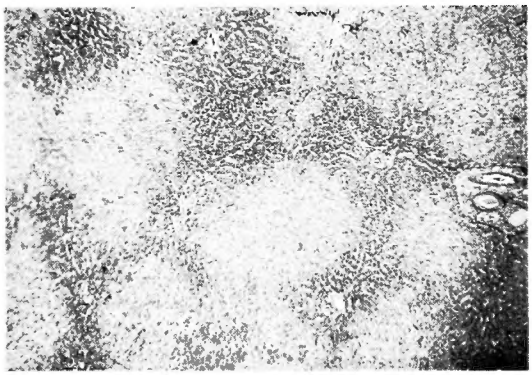
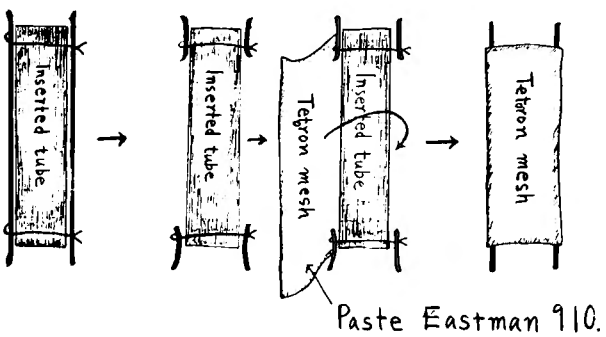


Fig. 15. Granulation in the both ends of inserted tube. (Dog No. 72, 157 days after portal tubing) (H-E×100)

III. EXPERIMENT OF WRAPPING WITH TETORON MESH AFTER STRIPPING OF PORTAL WALL OF TUBING SITE

Fig 16. Stripping of portal wall around inserted tube and wrapping with tetoron mesh.



1. Materials and methods

A. Materials

i. Tetoron mesh

ii. Adhesive paste of Eastman 910

B. Methods

Adult mongrel dogs were subjected to the experiment. Vinyl tube was inserted into the portal vein under anesthesia of intravenous injection of ravonal of 13 mg/kg body weight and ether inhalation.

Fig. 17. Stripping of portal wall around inserted tube.

Fig. 18. Wrapping with tetoron mesh after stripping of portal wall.

Table 4. Stripping of portal wall around inserted tube.

Dog No.	Time of interruption (min.)	Result	Finding of inserted tube
91	10.00	survival	Inadequate adhesion after 1 week.
92	6.00	survival	Adequate adhesion after 3 weeks and bled by stripping off.
93	7.00	survival	Completely enclosed by surroundig tissue and both ends of tube being occluded by granulation.
94	7.30	survival	Adequate adhesion after 3 weeks.
95	11.00	death	Sliding off from end of intestinal side of portal vein.

Both ends of the tube were fixed with silk-thread.

i. Portal wall was stripped off as in Fig. 16. (Group of portal wall stripping).

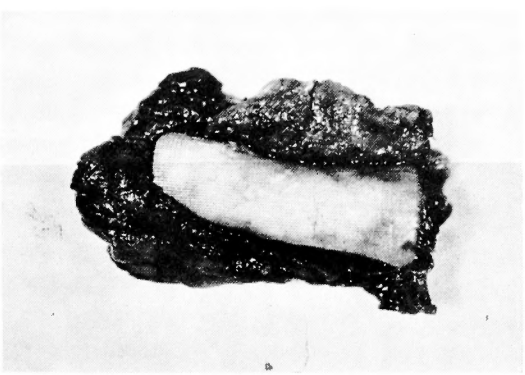
ii. Deficit of portal wall was wrapped up with tetoron mesh and coated with adhesive paste of Eastman 910 (Group of tetoron mesh wrapping after stripping of portal wall).

2. Results

1) Group of portal wall stripping

As in Tab. 4, the experiment was carried out in 5 animals. Interval of time required for interruption was 6 to 11 minutes. Out of 5 animals, survival was observed in 4 cases and a single lethal case. Appearance of site of the tube was observed 1 week, 3 weeks and 2 months after the stripping. Adhesion to the surrounding tissues was inadequate 1 week after the operation, which was so adequate 3 weeks after the operation as to bleed by violent separation. Two months after the operation, the tube was completely embedded in the surrounding tissues, transitional portion of the portal vein and the tube was entirely occluded by granulation. Cause of death in one case was clarified by autopsy to be hemorrhage occurred 3 hours after the operation due to sliding off of the inserted vinyl tube at the end of intestinal side.

Fig. 19. Specimen of tetoron mesh, 62 days after wrapping.



2) Group of wrapping with tetoron mesh after stripping of portal wall

Since there was a case of death due to sliding off of the tube in group of portal wall stripping, tetoron mesh was wrapped around the stripped portion with adherent paste of Eastman 910. Experiment was carried out in 6 animals. Interval of time required for interruption was 5 minutes and 30 seconds to 9 minutes. All the animals survived. Appearance of wrapping with tetoron mesh was slightly unfavorable in 2 cases and satisfactory in 4 cases. There was no possibility of sliding off of the tube in all the cases 1 week after the operation. There was complete adhesion around the site of wrapping 4 weeks after the operation. The site of wrapping was embedded in the surrounding tissues. Both ends of the tube was occluded by granulation, and the middle of the tube was filled with fibrin-like substance (Tab. 5 and Fig. 19).

3) Histological finding of portal vein of tubing site in groups of 1) and 2). (Fig.

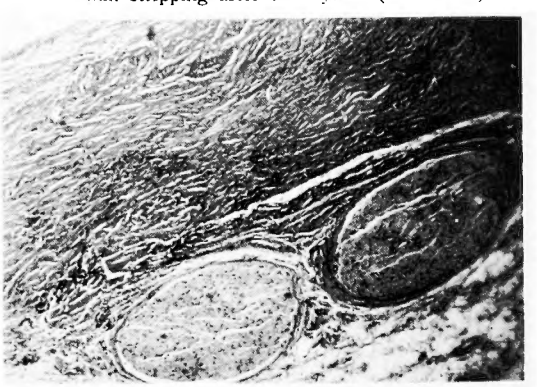
Table 5 Wrapping with tetoron mesh after stripping of portal wall around inserted tube.

Dog No.	Duration of time of interruption (min.)	Result	Finding of tetron mesh	Finding of inserted tube
96	9.00	survival	slightly unsatisfactory	Without possibility of sliding off after 1 week.
97	6.00	〃	satisfactory	〃
98	6.00	〃		Adhesion to surroundings after 4 weeks.
99	8.00	〃	〃	〃
100	5.30	〃	〃	Enclosed by surrounding tissue, being completely occluded with granulation.
101	8.00	〃	slightly unsatisfactory	〃

Fig. 20. Finding of granulation in the both ends of inserted tube in animal of tetoron mesh wrapping after 62 days. (H-E ×100)

Fig. 21. Finding of portal wall in animal of tetoron mesh wrapping after 62 days. (H-E ×100)

Fig. 22. Finding of portal wall in animal of the wall stripping after 57 days. (H-E×100)



20, 21 and 22).

Inserted tube was gradually surrounded by granulation of foreign body inflammation in both groups. Degeneration of muscle fibres and infiltration of granulation into muscle layer were observed in portal wall close to the tube. Both ends of the tube were completely occluded by granulation proliferated from the surroundings and the middle of the tube was filled with fibrin-like substance 2 months after the portal tubing.

IV. DISCUSSION

The most difficult problem in pancreatoduodenectomy for cancer of the head of the pancreas is the treatment of the portal vein already encountered adhesive infiltration[8,16,30,41]. Bleeding from the portal vein and splanchnic area at isolation of the pancreas should be

minimized and if portal interruption is inevitable, duration of time of the interruption should be shortened as possible in order to lessen the operative aggresion[49]. In this purpose, the author of the present experiment devised a method of pancreatectomy in which the portal vein is protected from the inside by an insertion of vinyl tube into the vein. By this procedure, bleeding is well minimized even if the portal wall be injured at the isolation. Here, a vinyl tube was inserted into the portal vein in experimental animals[11,17,18] and time of portal occlusion due to thrombus formation within the tube was examined without using anticoagulant of any kind. Portal occlusion due to thrombus formation occurred at the inserted site 20 to 62 hours after the tubing being accompanied by a rapid elevation of portal pressure, and at the same time there developed hepatopetal collaterals through the portal vein—superior mesenteric vein—jejunal vein—inferior pancreatoduodenal vein—superior pancreatoduodenal vein—gastroduodenal vein—portal vein, which was ascertained by portalography and autopsy. It was further clarified that portal pressure restores to almost normal level and stabilizes after the operation. KIKUCHI[26,27] observed in experiment that hepatopetal collaterals develops through the venous plexus around the common bile duct, inferior pancreatoduodenal vein and pyloric vein and hepatofugal collaterals develops sometimes through the esophageal vein and inferior hemorrhoidal vein, and sometimes through the inferior mesenteric vein, left spermatic vein and left proper renal vein. Date[12] observed in dogs that hepatopetal collaterals through the inferior pancreatoduodenal vein, superior pancreatoduodenal vein, portal vein and liver was invariably established and development of hepatofugal collaterals anastomosing to the system of the inferior vena cava was not prominent.

As it was considered that the gastroduodenal and superior mesenteric veins, particularly its 1st and 2nd branches, have an important significance in the establishment of hepatopetal collaterals caused by portal occlusion due to thrombus formation following the portal tubing, experiments were carried out in 3 groups. In the group of severance of the gastroduodenal vein and that of the superior mesenteric vein, all the animals died within 4 to 6 hours. On the contrary, animals survived in 77% in the group without severance of both the gastroduodenal and superior mesenteric veins. It was clarified that participation of the gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein is indispensable in the establishment of collaterals after portal occlusion due to thrombus formation.

As control of above mentioned 3 groups, acute portal interruption was carried out at the liver hilum and the intestinal side of the splenic vein draining in the animals without severance of both the gastroduodenal and superior mesenteric veins. All the animals died within 2 hours and 40 minutes to 4 hours. From these findings, it is assumed that acute portal interruption is lethal even in dogs without severance of both the gastroduodenal and superior mesenteric veins, while 1st and 2nd branches of the superior mesenteric vein, intestinal, pancreatoduodenal and gastroduodenal veins are utilized as collaterals as portal pressure reaches a certain level by portal occlusion caused by thrombus formation, since a preparative condition is accomplished in these veins during the process of gradual occlusion following portal tubing.

DANIEL[11] performed for the first time 'portal bridging' with a plastic tube in portal deficit in dogs with the result of portal occlusion due to thrombus, and he observed development of collaterals just before the thrombus formation.

KIKUCHI made an experiment of homotransplantation using polyethylene tube as a core and venograft preserved in 70% alcohol. Portal occlusion due to thrombus was observed in all cases and 7 animals out of 12 survived.

Of course, it is desirable that the inserted tube remains to be patent for long after portal tubimg. However, when vinyl tube is inserted, permanent patency cannot be expected owing to difference in hardness and elasticity of wall of the tube from those of the portal vein and vortical blood flow in the inserted tube. INOUE[22] performed vinyl tube transplantation by hand suture with silk-thread in the abdominal inferior vena cava and superior vena cava. He reported that the tube was not occluded by thrombus for more than 6 months in 2 cases out of 13, and intima formation was also observed. The reason of long patency of the tube must be attributed to anticoagulant used in his experiment. It is widely known that formation of intima cannot be expected unless materials having porosity are used, such as Tetoron, Teflon, Nylon, Dacron, Orlon or Ivaron[2,20,21,28,32,45].

The principal aim of the present experiment does not consist in obtaining the long patency of the portal vein, but in obtaining patency of the portal vein, even though short period, in which blood supply is maintained to the liver, on the other hand development of collaterals being prepared. In this respect, the intention resembles that of 'two stage operation' postulated by CHILD. In his operation, the portal vein is occluded in the 1st operation in the aim of developing collaterals, and at the 2nd operation the portal vein is simultaneously resected with pancreatoduodenectomy. BRUNSCHWIG and NEUHOF[34] also reported that the portal interruption can be safely carried out after adequate development of collaterals induced by gradual constriction of the portal vein.

It is a matter of fact that the portal tubing premises temporary interruption of the portal flow, and in shortening the duration of the interruption technical simplicity of the tubing procedure is required. As has been reported by NEUHOF, ORE, ELMAN, COLE[14], BOYCE[5] and others, acute portal interruption is invariably fatal in an organism in which collaterals are not established before the interruption. Accordingly certain management is required such as shortening the duration of the interruption, external shunt or temporary interruption of the arteries draining into the splanchnic area. PECK[36] reported that portal interruption was safely carried out by external shunt from the portal trunk to the femoral vein, and BARNETT[4] also succeeded in safety interruption of portal flow by external shunt from the splenic vein to the femoral vein. Permissible time of portal interruption under interruption of the arteries draining into the splanchnic area is reported by NELSON[33] to be 2 hours, by MOORE[31] to be 95 minutes and by OYANAGI[35], in our clinic, to be 60 minutes. It is also reported that the permissible time can be further prolonged by hypothermic anesthesia.

Permissible time of simple portal interruption without management as mentioned in the above is reported by DANIEL to be shorter than 14 minutes in his experiment of portal vein transplantation in dogs, and DATE reported that the interruption was safely carried out until 10 minutes and if the interruption exceeded this limit, shock became irreversible. Procedure of portal tubing in the present experiment is very simple and duration of time required for the tubing is 4 to 14 minutes. If pancreatoduodenectomy is carried out during the portal flow is maintained after release of the portal interruption, bleeding from injury of the portal wall can be minimized and procedure of portal vein isolation can be performed

with ease, largely contributing to the improvement of resectability of pancreatoduodenectomy.

In the present experiment, portal wall around the inserted tube was further stripped off, in order to examine the possibility of simultaneous resection of the portal vein with pancreatoduodenectomy. A week after the tubing, adhesion around the inserted tube was inadequate. Three weeks after the tubing, adhesion was satisfactory, and the inserted tube was completely enclosed with the surrounding tissues 2 months after the tubing. In a case, hemorrhagic death was experienced due to sliding off of the inserted tube from the portal vein.

Hereupon, a tetoron mesh was twisted with adhesive paste Eastman 910 around the exposed tube after stripping of the portal wall of tubing site. There was no possibility of sliding off of the inserted tube, the appearance of the twisted cloth being satisfactory.

Liver function of long surviving dog after portal tubing showed no abnormality, as determined by B. S. P. retention test. No abnormal finding was observed electrocardiographically, and weight loss of experimental dogs was not observed.

V. SUMMARY

Pancreatoduodenectomy for cancer of the head of the pancreas is technically complicated and aggresive operation. For the improvement of resectability of pancreatoduodenectomy, it is of utmost importance to minimize bleeding from the portal vein and splanchnic area and, if necessary, to resect a portion of the portal vein.

The author of the present experiment studied the possibility of simultaneous resection of the portal vein with pancreatoduodenectomy in dogs, in which a vinyl tube being inserted into the portal vein for protection of portal flow and prevention of hemorrhage. Results obtained are summarized as follows:

1. Portal occlusion due to thrombus formation occurred 20 to 62 hours after insertion of vinyl tube into the portal vein. The portal vein was occluded at the site of portal tubing with a rapid elevation of portal pressure. Almost simultaneously with the portal occlusion due to thrombus, there developed hepatopetal collaterals coursing through the portal vein—superior mesenteric vein—jejunal vein—inferior pancreatoduodenal vein—superior pancreatoduodenal vein—gastroduodenal vein—portal vein. Portal pressure restored to almost normal level as the collaterals were established.

2. The gastroduodenal vein and 1st and 2nd branches of the superior mesenteric vein had an important significance in the development of the collaterals after the portal occlusion due to thrombus formation.

3. Animals invariably died following acute portal interruption, even if the gastroduodenal and superior mesenteric veins were preserved. However, in animals of portal tubing, development of collaterals were prepared during the gradual occlusive process in the portal vein, in 1st and 2nd branches of the superior mesenteric vein, pancreatoduodenal and gastroduodenal veins, which worked as collaterals as portal pressure reached to a certain level after portal occlusion due to thrombus formation, and the animals did not die.

4. If a vinyl tube is inserted into the portal vein at pancreatoduodenectomy, and the pancreas is isolated from the portal wall, massive hemorrhage may well be prevented at injury of the portal wall, and repair of injured wall can be done with ease.

5. Procedure of the portal tubing being very simple, interval of time of portal inter-

ruption required for the tubing is also very short.

6. After stripping of the portal wall of the tubing site, tetoron mesh was twisted around the exposed vinyl tube, and there was no possibility of sliding off of the tube. By this procedure, safety bridging of the portal vein will be carried out, largely contributing to the improvement of resectability of pancreatoduodenectomy.

I am deeply indebted to Prof. Dr. ICHIO HONJO for his valuable advices and kind encouragement throughout the experiment, I am also grateful to Dr. NAKAGAMI, Dr. FUKUYAMA and other members of our clinic for their kind helps.

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(* in Japanese)

和文抄録

門脈内ビニール管挿入に関する実験的研究

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膵頭部癌に対する膵頭十二指腸切除術は，技術的にも煩雑で侵襲の大なる手術である。膵頭十二指腸切除の切除率を向上せしめんがためには，門脈及び門脈領域からの出血を可及的少くする一方，門脈の同時切除も実施されねばならない．

私は実験動物犬の門脈内に塩化ビニール管を挿入し，これを支柱とする膵頭十二指腸門脈同時切除の可能性を検討し，興味ある知見を得たので報告する．

(1) 門脈内塩化ビニール管挿入後，門脈栓塞の時期は20～62時間で，管挿入部で門脈圧の急激な上昇と共に栓塞を来し，門脈栓塞と殆んど同時に門脈，上腸間膜静脈，小腸静脈，下膵十二指腸静脈，上膵十二指腸静脈，胃十二指腸静脈，門脈と経過する求肝性副血行路が発現し，門脈圧は正常域に復帰する。

(2) 門脈栓塞後の副血行路形成に関し胃十二指腸静脈，上腸間膜静脈第Ⅰ，Ⅱ枝が重要な役割をもっている．

(3) 胃十二指腸静脈，上腸間膜静脈を切断しなくとも，門脈急速遮断をおこなえば実験犬は死亡するが，塩化ビニール管を挿入することにより上腸間膜静脈第Ⅰ，Ⅱ枝，小腸静脈，膵十二指腸静脈，胃十二指腸静脈において，挿入管の逐次的栓塞進行中に副血行路形成の準備状態ができており，門脈栓塞後一定の門脈圧値に達すると同時に副血行路として働らき動物は死亡しない．

(4) 膵頭十二指腸切除に際して，門脈に塩化ビニール管を挿入し，これを支柱として膵を門脈壁から剝離すると，門脈壁を誤って損傷しても大出血を招来することなく，その管壁の修繕も容易である．

(5) 塩化ビニール管挿入の手技は極めて簡便であり，挿入時に行なう門脈遮断も短時間でよい．

(6) 管挿入部の門脈切除後，テトロンメッシュ巻きつけにより，管滑脱の危険もなく，膵頭十二指腸と門脈の同時切除に際して門脈の安全なるブリッジングをおこない得て，膵頭部癌の切除率向上に資するところがある．